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DYNAMICAL MODELS AND MASS FORMULAS FOR RESONANCE MULTIPLETS*

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It is customarily assumed that if SU(3) is a valid symmetry, resonances will occur in complete SU(3) multiplets. It is equally customary to assume that (except for mixing effects, which we do not consider) the masses in a resonance multiplet will satisfy a mass formula of the usual type. A related assumption is that mass formulas for Regge recurrences will be the same as those for the lowest member on the trajectory. The purpose of this note is to suggest that for multiplets which can be obtained by dynamical arguments based on forces generated by unitarity and inelastic effects, these assumptions about mass formulas may not be correct. Such multiplets may include the Regge recurrences of the baryon octet and decuplet, the multiplet which contains the $N_{1/2}^*(1518)$, and others.

To see this we first recall that Cook and Lee,[1] and Auvil and Brehm,[2] have proposed to account for the existence of a number of resonances by considering the strongly attractive forces provided by coupling inelastic channels through unitarity. In these models the inelastic amplitudes are driven by single-particle-exchange contributions. The work of Wali, Warnock, and Ernst[3] has made it plausible to conjecture that amplitudes constructed from single-particle exchanges will exhibit mass splittings consistent with octet symmetry-breaking assumptions, whenever the input particles do so. Because unitarity couples the square of the inelastic amplitude to the elastic channel, the resulting elastic amplitude will include contributions to a mass formula from all the terms in the product of two octets. Okubo[4] has derived the mass formula for this situation. In general, it contains six arbitrary parameters, so for octets it will not lead to any relations at all among the four masses. For the 10 and 10* multiplets the relation $I=\frac{1}{2}Y+1$ holds[4] and the general formula reduces to $M=M_0+M_1Y+M_2Y^2$. In this case there is one relation among the split masses.

Note that the effect of the Y^2 term need not be proportional to the square of the coefficient of Y in the input mass formulas, because several product terms occur, giving enhancements (or cancellations); and, in addition, they occur with scales set by different couplings. On the other hand, dynamical calculations such as those we are considering will give heavier output masses to resonances involving heavier input masses, so that the resonance mass will tend to increase with hypercharge. Thus the deviation from a mass formula with mass also increasing with hypercharge is not likely to be a large effect.

These arguments appear to imply that the mass splittings inside resonance multiplets are not likely to satisfy the usual mass formulas.[5] Of course, it is possible that some more subtle situation holds, and mass formulas will continue to hold to good accuracy (this would occur if cancellations occurred and some of the six coefficients in the general formula were small). This is not inconsistent with the dynamical models but would suggest either that we do not understand all of their implications or that they are inadequate to account for all of the properties of the observed resonances.

One resonance which has been obtained in such models[1] is the $J^P=\frac{3}{2}^-$ $N_{1/2}^*(1518)$, expected to be an octet member.[6] It has proved quite difficult to complete this octet by the usual methods. Our considerations may help account for this by making it unlikely that the usual mass formula should be satisfied. Similarly, Auvil and Brehm[2] have proposed that the Regge recurrences of the baryon octet and decuplet follow from such a model, so again we would not expect the former to satisfy a mass formula, while the latter could at best satisfy $\Omega_0^*=N_{3/2}^*+3(\Xi_{1/2}^*-Y_1^*)$, rather than an equal-spacing rule. Another application[7] is to a possible resonant 10*, where a linear mass formula could lead one to expect very light strange particles, but these considerations indicate that one should expect a single relation of the form $\Xi_{3/2}{}^{*}=Z_0+3(Y_1{}^{*}-N_{1/2}{}^{*})$.

Unfortunately, these considerations, if valid, will make it more difficult to assign confidently resonances to SU(3) multiplets. On the other hand, calculational techniques may eventually develop to the point where the various masses and decay widths could be estimated, by using physical input masses one hypercharge and isospin channel at a time, for multiplets where classification proved difficult. Such calculations would then also allow one to relate decay widths into different multiplets.

Though such models have not yet been studied for meson states, it is clear that similar effects will be expected when they are.

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$\bar{p}p$ ELASTIC SCATTERING FOR INCIDENT MOMENTA BETWEEN 1.0 AND 2.50 BeV/c*

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This is a report on a measurement of $\bar{p}p$ elastic scattering for $30° \leq \theta_{c.m.} \leq 90°$ and for incident momenta between 1.0 and 2.50 BeV/c. In the past rather extensive counter measurements[1] of this cross section have been made at high energies and low momentum transfers, but little counter data exist at large momentum transfer. The hydrogen bubble chambers[2,3] have produced data between 3.0 and 4.0 BeV/c, but the number of events at large momentum transfer is limited and the statistical accuracy is poor. These data show a diffraction peak in the forward direction with a cross section $\sigma(t) \sim e^{-At}$ for $t < 0.4$ (BeV/c)^2. The data we report on here agree with this general behavior for low t, but in addition show a pronounced minimum in the cross section in the neighborhood of $t = 0.4$ (BeV/c)^2, followed by a secondary maximum. We would like to suggest that this effect arises in the same manner as the minimum seen in pion-nucleon scattering and charge-exchange experiments at a similar value of t. A detailed discussion of this point is given in the accompanying Letter.[4]

The experiment was arranged in the following manner. An electrostatically separated antiproton beam, which provided useful fluxes of antiprotons in the momentum range between 0.75 and 3.0 BeV/c, was constructed at the Brookhaven alternate gradient synchroton (AGS). The ratio $\pi^-/\bar{p}$ was generally less than one and the antiprotons were easily identified by time of flight. This separated beam was focused on a 2-m-long liquid hydrogen target. Arranged